Circulation Characteristics of Puget Sound Related to Understanding Hood Canal

Glenn A. Cannon, School of Oceanography, University of Washington

Keywords: circulation, Puget Sound, Hood Canal, Saratoga Passage, deep water replacement

Abstract

Hood Canal has relatively weak circulation compared to other parts of Puget Sound. Replenishment of bottom water results entirely from flow over the entrance sill. It probably occurs less frequently than in the other basins, and contributes to greater stagnation of bottom water. There have been relatively few long-term current meter observations making it difficult to determine the replacement processes. Newly analyzed observations from winter-spring 1980 show intrusions occurring in the Main Basin but not in Hood Canal. CTD observations show less dense water in Admiralty than in the bottom of Hood Canal. Bottom salinity and temperature were more characteristic of the previous fall when the basin was likely last flushed. Fall flushing could force low-oxygen water nearer the surface, and wind events could then cause it to reach the surface and contribute to fish kills. Long-term current meter observations could greatly contribute to the new studies to understand Hood Canal.

Background

Puget Sound is an estuarine system that is made up of a number of smaller estuaries. Long-term current meter observations have been a major tool in determining the causes of flow patterns in the Main Basin. Vigorous circulation coupled with flow through The Narrows keeps bottom water from stagnating. More limited observations in Saratoga Passage show markedly different flow characteristics. Circulation is relatively weaker, and low oxygen occurs in the fall. However, the flow is coupled with Skagit River outflow through Deception Pass, that is smaller but similar in concept to The Narrows flow, and this may help keep the deep water from stagnating. Flow in Hood Canal appears to be even weaker than Saratoga Passage.

This talk reviews observations in Hood Canal and the Main Basin from a PMEL study in 1980 that were not fully analyzed.

Figure Notes (figures available from author)

1. Mooring example with Aanderaa current meters.

2. Mooring locations used in Fig. 3. Two in the Main Basin and Hood Canal were simultaneous in 1980.

3. Mean current profiles (top). Yellow is Main Basin simultaneously with black in Hood Canal. Hood Canal had weakest flow, two layers, with a likely third outflowing layer at the surface.
Salinity section along Admiralty Inlet and Main Basin (bottom). Entrance to Hood Canal is near mooring A, and bottom salinity was about 30.7, less than in the bottom of Hood Canal shown in Fig. 7. An intrusion with salinity of about 30.0 was flowing into the Main Basin.

4. Salinity through The Narrows on flood and ebb currents. Large flood currents draw water from depths in the Main Basin deeper than the sill, contributing to the relatively fast flushing of the Main Basin.

5. Salinity and sigma-t in Saratoga Passage before and after a bottom-water intrusion. Low-oxygen water is pushed to shallower depths by the intrusion enabling more mixing. Some water flows out Deception Pass, also contributing to mixing of the low-O2 water.

6. Tidal currents and salinity near surface and near bottom in Hood Canal. Magnitudes of these flows were much smaller than elsewhere in Puget Sound and are smallest near bottom.

7-9. Vector currents, salinity, and temperature (low-pass filtered to remove tides) from the mooring in Hood Canal in 1980. The green vertical line on 26 Feb is the time of the salinity section in Fig. 3. No bottom intrusions occurred, and the bottom salinity was almost 31.0, greater than in Admiralty Inlet. Bottom temperatures also were higher than those above sill depth. The other vertical green line shows

increased inflow near surface, that may be the result of winds, either to the south causing reversing the entire surface flow, or to the north with compensating south flow at depth.

10. Currents, salinity, and temperature from the mooring in the Main Basin. The bottom water intrusion on 26 Feb was shown in the salinity section in Fig. 3. The Main Basin had mixed sufficiently to allow intrusion of water with a salinity of 30. Bottom temperatures were colder than in Hood Canal.

11. Temperature, salinity, and currents from a year-long mooring in 1975-76 at the same location as Fig. 10. Water with T greater than 10 and S near 31, as observed in Hood Canal in Feb 1980, only occurred in the fall. Thus, Hood Canal may only flush in the fall because mixing of bottom-water from the previous was very slow. Flushing of both the Main Basin and Saratoga Passage were shown to be faster in Figs. 4-5.

Summary of Observations in Hood Canal

1. Tidal currents are relatively weak below sill depth.

2. Mean flow may be 3 layered other than during deep intrusions.

3. Deep-water properties in winter resemble the previous fall.

4. Mixing is slower than elsewhere in Puget Sound preventing intrusions.

5. Deep water may only be replaced yearly in the fall, or less in dry years.

6. Winds were not considered but are important (Kawasi, 2005).

Recommendation

A year-long current meter mooring deployed in the deep basin of Hood Canal, with temperature and salinity sensors at least in the near surface and bottom, could greatly assist understanding the processes causing distributions of water properties, including the low-oxygen changes. Simultaneous moorings on the sill and outside of Hood Canal would further this understanding.

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Acknowledgements

Curt Ebbesmeyer for many discussions on circulation in Puget Sound; Dave Kachel for help with figures.